National Aeronautics and Space Administration

Glenn Research Center
Cleveland, Ohio

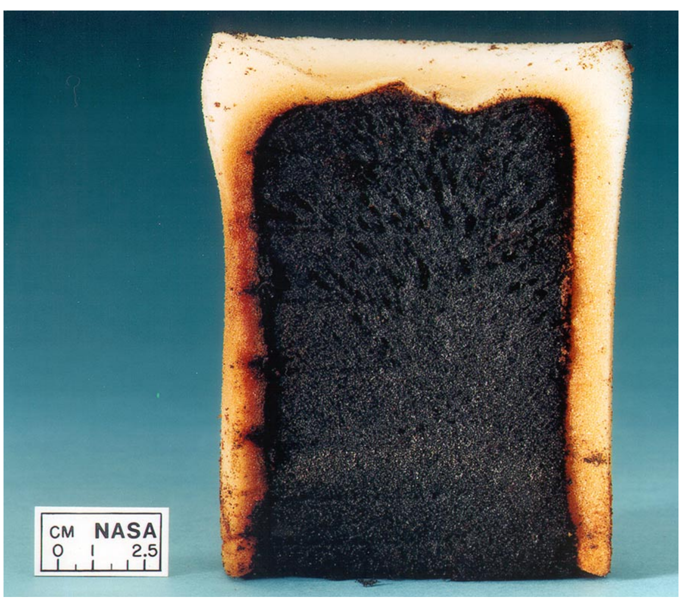
Microgravity Smoldering Combustion STS–105

Where There's Smoke . . .

Smoldering combustion is a complex, nonflaming form of burning that occurs in the interior of porous, combustible materials. These materials can be natural (piles of leaves and pine needles) or man-made (furniture stuffing and cable insulation).

Smolder, which can release toxic byproducts and burst into flames, is a serious problem: 40 percent of all deaths caused by fire in the United States can be attributed to the smoldering of household furniture. Obviously, the danger is even greater in space, where one cannot easily flee a burning space facility.

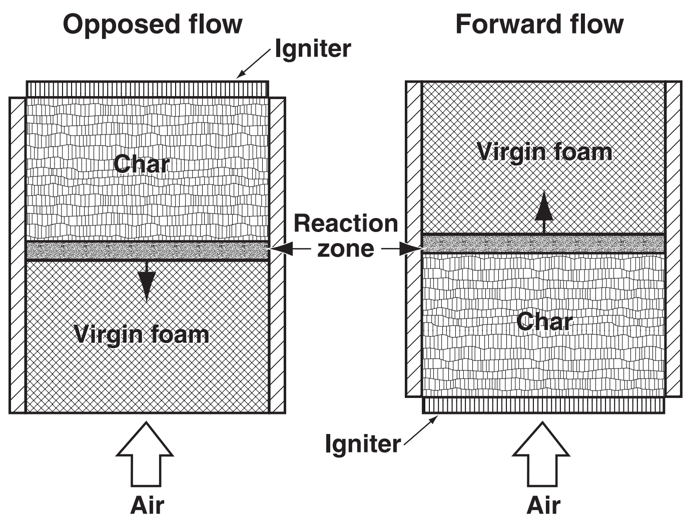
The Microgravity Smoldering Combustion (MSC) experiment has been developed by NASA Glenn scientists and academic investigators to examine smolder processes—as typified by a polyurethane foam sample in a fireproof cylinder—in normal gravity and in microgravity (extremely low gravity). The microgravity setting is especially valuable because it permits scientists to study smoldering combustion processes without the obscuring effects of normal gravity.



Smolder pattern in a polyurethane foam sample.

Experiment Basics

The MSC experiment consists, essentially, of heat, fuel, and air. The heat is provided by an igniter; the fuel in which the smoldering combustion takes place is polyurethane foam; and the air is various mixtures of oxygen and nitrogen. The most important variables relate to the air mixture, whether it is moving or not and, if so, the direction (that is, in the same direction the smolder combustion is traveling or in the opposite direction).



Opposed flow and forward flow schematic

In addition to testing smoldering combustion in still air, scientists also study smolder in environments of moving air. As shown above, the airflow can be moving with the smolder combustion (forward flow) or against it (opposed flow).

Science Objectives

The objective of the MSC experiment is to study the effects of oxygen flow rate and direction, without the confusing effects of buoyancy, on smoldering combustion. This will improve our ability to predict smolder behavior in fires.

Benefits

By increasing our fundamental understanding of smoldering combustion, the MSC experiment will improve our ability to predict and prevent smolder-originated fires on Earth and in space.

Previous Results

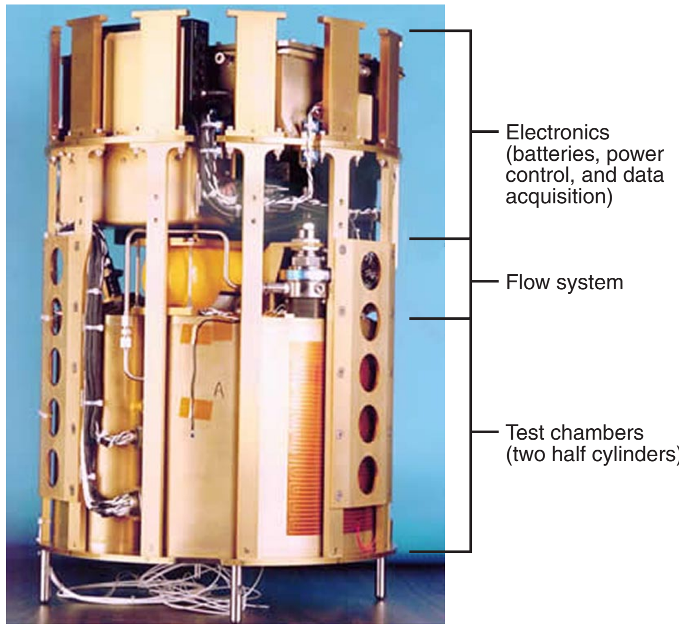
The first series of microgravity smoldering combustion experiments that flew aboard STS–69 and STS–77 in 1995 and 1996 revealed that the elimination of gravity-caused convection reduces both the oxygen supply and the transfer of heat to and from the reaction zone. (The characteristics of the smolder reaction are controlled by the competition between the transport of oxygen and heat to the reaction zone and transport of heat away from the reaction zone.)

A comparison of the tests conducted in normal gravity and microgravity showed that there are minimal fuel sizes and oxygen flow rates that are needed for a self-propagating smolder reaction, and these are significantly smaller in microgravity than in normal gravity. This finding has important implications for fire safety in a space-based environment since smolder can begin at lower oxygen flows or with less fuel than in normal gravity.

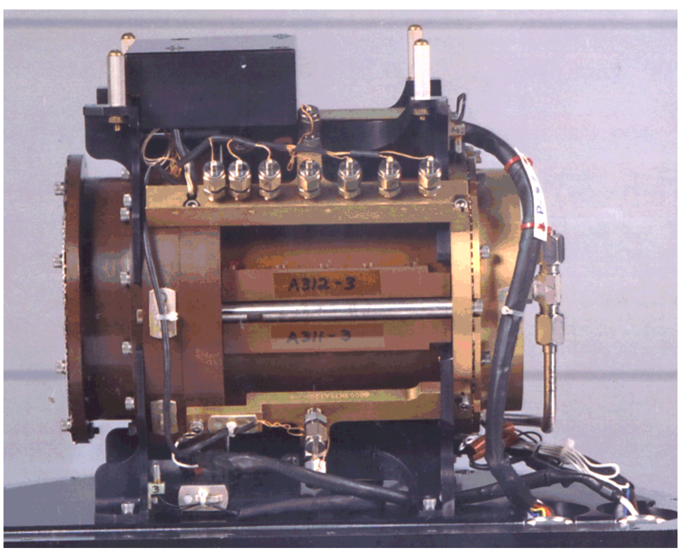
Hardware

The smolder experiment is conducted in a pair of 20-liter, hermetically sealed, semi-cylindrical, aluminum combustion chambers. The test section assemblies—which contain the 120-mm-diameter by 140-mm-long polyurethane foam fuel samples—are located inside the combustion chambers. As shown in the photo below, the test section assembly consists of a fire-resistant Vespel® cylinder; a cylindrical disc igniter (an electrically heated wire sandwiched between two porous ceramic discs and in contact with the end of the foam cylinder); a vessel housing for the char samples (which measures 120-mm by 52-mm long); and aluminum support brackets.

The MSC flight assembly (below) consists of three components: two combustion chambers at the bottom of the assembly; an airflow system in the middle of the assembly; and the electronics on top. The flight assembly, in turn, is placed in a Get Away Special (GAS) canister, which is a protective enclosure stored in the cargo bay of the Space Shuttle.



The MSC flight assembly.



MSC fuel sample and test section assembly.

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For more information, please visit the
NASA Glenn Microgravity Combustion web site at
http://microgravity.grc.nasa.gov/combustion/

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